THE RAPID PLANT BUG, ADELPHOCORIS RAPIDUS (SAY)(MIRIDAE), WITH ESPECIAL REFERENCE TO ALFALFA INJURY

by

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INTRODUCTION

The rapid plant bug, Adelphocoris rapidus (Say), belongs in that category of economic insect pests whose damage, though undoubtedly real, is usually not severe, concentrated, nor spectacular enough to attract much attention. It is very common in alfalfa and clover fields, and among such herbs as occur along roadsides, and in meadows. From an ecological point of view, and in respect to general habits, it closely resembles the more commonly known and usually more abundant tarnished plant bug, Lygus pratensis (Linn.).

Lack of recognition of the injury attributable to these and similar species, especially on the part of the lay observer, is largely because of three facts: (1) the injury is scattered, (2) plants attacked are not completely destroyed nor defoliated, and (3) secondary results of feeding, such as flower drop of alfalfa, may not be associated by the observer with the insect responsible.

During the fall of 1937 and the year 1939, a study of the life history and habits of the rapid plant bug was carried on, with especial attention to its relationship to alfalfa. This paper embodies the results of that study, together with a summary of the literature.

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HISTORY AND SYNONOMY

The rapid plant bug was first described by Thomas Say, in 1831, as Capsus rapidus (21). Herrich-Schaeffer described it as Capsus multicolor in 1848 (48). Glover (13) next called attention to the presence and feeding of this

insect on cotton. Glover did not indicate the species, but both his description and a figure fit the rapid plant bug so perfectly that there seems no doubt as to the identity of the insect to which he referred.

In 1872, Uhler (44) reported the rapid plant bug from Colorado, and stated that "the reddish variety extends as far west as San Francisco." He called it Calocoris rapidus. Uhler commented on the variation exhibited by western specimens in regard to color and pattern, as compared with the uniformity of specimens taken in the Atlantic region. It appears quite probable that at least a portion of his specimens were Adelphocoris superbus, a species described by him in 1875. The most obvious differences between typical specimens of these two species involve color.

In 1876, Glover reported Calocoris rapidus very common on Eupatorium in Maryland, and the following year mentioned its injury to cotton (15).

Uhler, in 1878, wrote of the rapid plant bug as belonging to the genus Dereocoris (45). The specimens discussed by him had been determined by Say, who may have been responsible for assigning the insect to Dereocoris. This genus was accepted by Forbes (8) when he reported the insect's abundance in strawberry fields. The generic name

Calocoris was retained, however, by many writers, among whom were Provancher (28), Riley (29), Van Duzee (46), Montgomery (23), Forbes and Hart (11), Sanderson (31), and Snow (34, 35). In 1908, Van Duzee (47) referred to the rapid plant bug as Adelphocoris rapidus, with the comment that "Dr. Reuter has separated this species and its allies from Calocoris." Reuter's paper establishing the genus Adelphocoris appeared in 1896, in a foreign publication which the writer has not seen, but since Reuter was familiar with rapidus as early as 1876, it would appear almost certain that he assigned it to Adelphocoris at the time of establishing that genus.

There have been several common names applied to Adelphocoris rapidus. Forbes (8, 9) referred to it as the "dusky plant bug", and later the same writer called it the "dusky leaf bug" (11). In the United States Department of Agriculture yearbook for 1905 the name "cotton leaf-bug" was used, indicating the economic significance which was coming to be attached to the insect. North of the cotton growing region the term "dusky leaf-bug" continued in use, as evidenced by the writings of Webster (52), and Weigel and Sasscer (54). Still another common name, "field plant bug", was used by Dean and Smith (5). The name "rapid

plant bug" was recently adopted by the American Association of Economic Entomologists' Committee on Common Names (4).

DISTRIBUTION, HOST PLANTS, AND ECOLOGY

Distribution

The rapid plant bug is widely distributed in North America. Plate I, Fig. 1, shows the distribution in the United States, based on records and on specimens seen by the writer. Various workers have reported the bug from the Canadian provinces of Alberta, Ontario, and Quebec.

Uhler (44) reported the rapid plant bug in collections taken by Coues or or near the parallel of 49°N., along the northern border of Dakota and Montana. Uhler (45) also wrote that it was a common species throughout the states east of the Mississippi river, and that it extended into Canada and British America. Forbes (7) wrote of the rapid plant bug as occurring from the Atlantic region to San Francisco. It was, he reported, less abundant than the tarnished plant bug, but still extremely numerous throughout Illinois. Blatchley (1) set the range of the insect from Quebec and New England to the Pacific, and southwest to Texas and New Mexico.

Although the rapid plant bug has been reported, in general statements, as occurring throughout the United States, it will be observed that on the distribution map (Plate I, Fig. 1), there is a large northwestern area represented only by Washington, from which a single specimen is in the collection of the Division of Insect Identification at Washington, D. C.

It is interesting to note that Adelphocoris superbus, which Blatchley (1) suggested might be but a western form of rapidus, is known from Arizona, California, Colorado, New Mexico, North Dakota, Oregon, Texas, Utah, and Washington.

A specimen from South Dakota has been seen in which the second antennal segment appeared to be that of A. superbus, but which seemed definitely like rapidus in other respects.

Host Plants

The rapid plant bug feeds on many plants, both cultivated and wild. Of the latter group, it seems to be particularly attracted to composites. Among cultivated plants, cotton and the legumes are favored.

The following is a summary of the literature on the

specific food plants of the insect.

Cotton. In his first mention of the rapid plant bug, Glover (13) described it as an insect which was found perforating the young flower-buds and bolls of the cotton. Later the same writer (15) reported injury to cotton foliage by the insect, but did not describe the injury in detail. Mally (22) stated that the insect was very common on cotton plants, usually being found between the involucres and bolls. The damage, he wrote, was done by puncturing the boll with the beak, leaving a small, round, black dot at the point of puncture, which often was mistaken for bollworm injury. The effect, according to Mally, was usually a flaring of the boll, with subsequent dropping, or staining of the cotton. In the United States Department of Agriculture Yearbook for 1905, the rapid plant bug was accused of injury to cotton bolls in North Carolina and Alabama (40).

Sanderson (30) reported that the insect caused considerable damage to cotton in northern Texas in August and September, 1904. Squares and young bolls were punctured, causing them to drop or to shrivel or decay where punctured. The punctures were said to give rise to small round black spots, resembling diseased places, gradually becoming larger and sunken.

In reporting the principal injurious insects of 1906 in the United States Department of Agriculture yearbook, the Bureau of Entomology and Plant Quarantine claimed the rapid plant bug to have been very abundant throughout Louisiana and eastern Texas, where it probably injured cotton to some extent by sucking sap from the cotton bolls (41). Sanderson (31) wrote further regarding the infestation in Texas during the latter part of the summer of 1904. He stated that a young cotton plant about eight inches high, on which six rapid plant bugs were caged, died within five days as a result of the injury. The black puncture marks, he wrote, did not, even under favorable conditions, show fungous development.

Smith and Lewis (33) mentioned the so-called "cotton-leaf bug" among cotton insects collected in Georgia in 1905, but reported no serious damage. Watson (49) stated that cotton in Florida had been injured by the insect, squares and young bolls dropping after having been punctured. The annual report of the Arkansas Agricultural Experiment Station for 1926 (42) carried an account of cotton injury by the "cotton leaf bug" that year, although it was stated that it had not previously attracted attention as a cotton pest. Isely (20) wrote that in Arkansas, in 1926, the

insect had caused the shedding of squares as large as an English pea. He stated that the period of greatest activity of the leaf bugs in the cotton fields that season was during the first month after the setting of squares began, with the climax of the outbreak occurring during late June and early July, with other hosts claiming major attention after July 15.

One of the best accounts of the nature of the injury done by the rapid plant bug is that by Ewing (6) who described its effect on the cotton plant. The effects of feeding he described as shedding or blasting of young squares, lesions along the main stem, branch stems, and leaf petioles, and leaf mutilations. He observed 12 cases of feeding, five of which were under five minutes, three between six and 15 minutes, three between 16 and 30 minutes, and one over 60 minutes. It was Ewing's opinion that the length of time of feeding seemed to have little if any effect on the extent of injury. His observations indicated that damage from Mirid punctures extends only a very short distance from the point of puncture, usually not over 2 mm.

Ewing and McCarr (7) reported a severe effect on the growth and fruiting of cotton plants as a result of infestation by Adelphocoris rapidus and other Mirids. Gaines

(12) wrote of extensive shedding of cotton squares because of abundance of hemipterous insects, of which the rapid plant bug was listed as one of the two most important.

Potatoes. Webster and Stoner (53) reported that rapid plant bugs caused some wilting of potatoes during July, 1913, at Ames, Iowa. They discovered the eggs in potato stalks, and apparently were the first to mention the egg stage. Webster (52) discussed the insect as a potato pest, and described the wilting of tender leaves on a potato plant on which 25 adult bugs were caged for four days.

Patch (26) included Adelphocoris rapidus in a list of insects collected from potatoes at Presque Isle, Aroostook county, Maine, in July, 1921.

Beans. Hawley (18) first called attention to ragged scars in beans which, he asserted, were caused by feeding punctures of Adelphocoris rapidus. He suggested that a toxic secretion might be involved. In 1922 the same writer discussed this problem further, showing that, as a result of feeding by the rapid plant bug, bean pods became misshapen, with dark, wart-like areas, and that such pods contained "dimpled" seeds. The most severe damage, according to Hawley, was to beans which were nearing maturity, but the pods of which were still green. Attacks on blossoms,

leaves, and stalks, although occurring, were said to have resulted in no serious deformation.

Pettit (27) discussed the rapid plant bug in connection with the dimpling of beans, calling attention to the work of Hawley, and describing in some detail the appearance of the "dimples."

Clover. Forbes (10) included red clover in a list of plants on which the rapid plant bug had been taken. Osborn (24) declared that rapidus had been known for many years to affect the clover crop. Watson (50) reported that it was found abundantly on grasses and clovers in Ohio, although not usually considered as a serious pest.

The insect has been found to be relatively abundant in clover at Manhattan, Kansas. A few experiments, involving the caging of rapid plant bugs on flowering white sweet clover plants, were made. Flower drop resulted, with subsequent development of very few seed pods, as compared with check plants. Both uncaged stems, and caged stems with bugs excluded, were used as controls.

Alfalfa. Forbes (10) included alfalfa in a list of plants on which the rapid plant bug was known to feed. Dean and Smith (5) listed it as one of the most common insects in alfalfa fields, and accused it of reducing seed production by feeding on the blossoms, causing them to drop.

Misshapen and poorly filled seed pods, resulting from feeding on the young pods, were also mentioned by them.

The findings of the present study regarding rapid plant bug injury to alfalfa are recorded later in the paper.

Other legumes. Isely (20) stated that Adelphocoris rapidus bred in large numbers on cowpeas and soybeans, and appeared to prefer these plants to cotton.

Strawberries. Abundance of rapid plant bugs on the fruit of strawberries in Illinois in the spring of 1883 was reported by Forbes (8, 9). Although he implied that injury resulted, no direct statement as to the extent or nature of such injury was made.

Apple. Stewart and Leonard (38) used apple shoots in experimentally proving that the rapid plant bug is capable of assisting in the dissemination of fire blight. Their findings, however, did not indicate that this role of the insect is a very important one in nature. Gossard and Walton (16) called attention to the ability of any sucking insect which feeds on infested twigs to transmit the disease to the next twig punctured, if the stage of development of the latter twig is favorable.

Wheat. Webster (51) reported that small numbers of rapid plant bug adults were observed on both fall and spring

wheat. A withering and shrinking of portions of the heads while the kernels were filling was noted, but it was not established that Adelphocoris rapidus was responsible.

Of interest in relation to Webster's observations are the results of experiments which were conducted incidental to the present study. Early in June, 1939, several adult rapid plant bugs were caged on wheat. One head and several inches of culm were included in each cage, the heads being still more or less green, although they were beginning to color. In most cases, the caged bugs died within a day or two, but one specimen remained alive for a period of seven days, and on the fourth day was observed with the beak in feeding position at the base of a glume. It would appear from this that at least moderately adequate nourishment can be obtained by the insect from the wheat plant just prior to ripening, the stage during which injury might be expected, if at all, because of the low rapid plant bug population earlier in the season, in this section of the country. No evidence of injury to wheat, however, was found in any of these experiments.

Corn. Forbes (10) wrote that the rapid plant bug had been seen many times on the leaves, silk, and ears of corn, frequently with the beaks inserted in the kernels at the tip of the ear.

Beets. In a paper on the economic entomology of the sugar beet, Forbes and Hart (11) mentioned the rapid plant bug as being a common species, but implied no well-marked damage to beets attributable to it.

Asparagus. Chittenden (3) wrote that the rapid plant bug was "not uncommon" in asparagus beds in America.

Buckwheat. In reporting insects taken by sweeping buckwheat, Riley (29) listed "Calocoris rapidus" as common in sweeps taken the last day of August and at intervals during September. It was not stated where this occurred.

Other hosts. In addition to the plants listed above, many other hosts, particularly among the uncultivated plants, have been mentioned by authors. In a list of hosts on which the rapid plant bug fed, Forbes (10) included celery, cabbage, rye, evening primrose, thistle, goldenrod, ragweed, and sumac. He stated that it had been taken on mulberry, as well as various grains and grasses.

Composites have been mentioned repeatedly as hosts. Van Duzee (46) wrote that the rapid plant bug was very common on flowers of the Compositae. Weigel and Sasscer (54) discussed the Compositae as hibernating quarters. Blatchley (1) reported the insect common in autumn on flowers on composites, especially ironweed and goldenrod.

Glover (14) in Maryland, and Provancher (28) in Canada, reported it on Eupatorium.

Both Britton (2) and Blatchley (1) wrote that the insect bred on Rumex, the latter author mentioning particularly R. crispus L. Pettit (27) reported it was most plentiful in places where lambs'-quarter and ragweed were allowed to grow.

Labels on specimens of Adelphocoris rapidus in the Kansas State College collection reveal that the following genera were included among plants from which they were swept: Aster, Solidago, Grindelia, Eupatorium, Helianthus, Xanthium, Kuhnia, Salvia, Polygonum, and Euphorbia. In the accession data relating to still other specimens, prairie clover was frequently mentioned as a component of a mixed plant community from which the sweepings were made. In one case it was recorded that the specimens were taken from a plum tree.

Ecology

Watson (50) described the rapid plant bug as a meadow insect. He wrote that it was found in shaded situations, but in decreasing numbers as the shade and moisture increase. Blatchley (1) reported that it occurred especially

on plants of moist localities.

It has been observed that caged specimens, both nymphal and adult, normally avoid the direct rays of the sun, remaining in the shade of the plant. Nymphs placed on bare soil in the sunlight, with a soil temperature of over 130 F., and an air temperature of approximately 105 F., were observed to succumb suddenly after only two or three seconds of frenzied activity.

Adults are commonly taken in light traps.

Snow (35) reported having taken the insect from Oak Creek canyon, near Flagstaff, Arizona, at an altitude of 6000 feet. Slosson (32) recorded it at or above 5500 feet altitude on Mt. Washington, N. H.

Weigel and Sasscer (54) called attention to the role of the rapid plant bug as an occasional greenhouse pest, indicating that it responds favorably to the relatively constant temperature conditions of such an environment.

LIFE HISTORY AND HABITS

Rearing Methods and Materials

To obtain eggs, it was found best to cage a female on a short length of stem, where the eggs might readily be

found. Two types of small cages were used. One consisted of a celluloid homeopathic vial, with the bottom and a small section of the side cut out and covered with gauze, or a similar material. This small cage was then fitted with a cork stopper, which was split in half, and a central portion cut out to permit its fitting about an alfalfa stem. The vial could then be slipped down over a stem and the stopper inserted. If there was too much clearance between the stopper and the stem, cotton was used as packing.

This type of cage has been used in various experiments for a number of years, and is quite useful. Often, however, conditions of abnormally high relative humidity appear to develop in it, and to avoid this, another cage was designed. This was similar in size and shape to the other, but consisted of 24-mesh wire cloth, formed into a cylinder and secured with adhesive tape. Cotton stoppers were used at each end. This type of cage provided more natural atmospheric conditions.

In either case the cage was supported by a stake. For experiments conducted in the shade, rubber bands are convenient for holding the cages to the stakes, but in the sunlight, the use of twine is advisable.

After a female had been caged for a day, she was

transferred to another stem, and the original stem cut for examination. If eggs were found, the cut stem was placed in a test tube, stoppered with cotton.

As soon as nymphs hatched, or were taken in the field, they were placed in individual cages. For this purpose the small wire cloth cages previously mentioned seemed to serve the purpose best. They were placed upright in shallow earthenware dishes containing wet sand, and a short portion of alfalfa stem, bearing blossoms, was placed in each one, the cut end pushed into the sand. The top was stoppered with cotton. New stems were entered each day, at which time exuviae were sought, for moulting records.

For infestation studies on alfalfa, clover and wheat, cylindrical cages of 16 mesh wire cloth, mounted on stakes, were used. The length of stakes used should vary, to accomodate plants of various heights.

With the exception of infestation studies, the majority of experiments were conducted in the insectary.

Hibernation

There has been a question as to how the rapid plant bug overwinters. Although he made no direct mention of the hibernating stage, Forbes (8) reported taking adults in March, which would seem to indicate overwintering in that

stage. Webster and Stoner (53), although they did not state it as a fact, expressed the belief that the adult hibernated. Next came a definite statement by Weigel and Sasscer (54) to the effect that the adults overwintered. It must be remembered that they dealt with the rapid plant bug as a greenhouse pest, and may possibly have based their statement regarding hibernation on its behavior in the greenhouse. Isely (20), working in Arkansas, reported that the insect wintered as an adult. Only within comparatively recent years has anyone stated that the rapid plant bug overwinters in the egg stage, in plant stems (50).

Efforts have been made to discover the overwintering stage in the vicinity of Manhattan, Kansas. Thus far, however, all evidence has been circumstantial, but it is thought to be strongly indicative of the facts.

Attempts have been made, repeatedly, to discover overwintering rapid plant bug adults, but to no avail, although the tarnished plant bug is found quite easily. On the other hand, eggs of Adelphocoris rapidus have been found in alfalfa stems taken from the field as late as November 29, which is later than any adults have been seen. Unfortunately, attempts to hatch such eggs in the greenhouse have been unsuccessful.

In rearing experiments carried on in the insectary

during the fall of 1937, no eggs laid after September 1 hatched, although oviposition continued until the first week in October. This would seem to indicate a diapause.

In 1939, alfalfa sweepings and light-trap collections were begun about the middle of March, in an attempt to find the rapid plant bug as soon as it appeared, and to ascertain the stage first appearing. The first individuals taken were two nymphs, either first or second instars, swept from alfalfa May 6. Thereafter, nymphs were taken at almost every sweeping, and in progressively advanced stages. From fifth instars swept from the field May 16, two adults, on male and one female, were obtained May 19, in the insectary. The first adults to be taken in the field were swept from alfalfa two days later. During the night of June 2-3, an adult was taken in the light-trap.

The above records would indicate, very strongly, that overwintering occurs in the egg stage in the vicinity of Manhattan. This also is supported by the fact that of 201 specimens of the rapid plant bug in the Kansas State College collections, taken at various times during the past 50 years, the earliest recorded date of collection was May 12, the latest November 2.

It is entirely reasonable to believe that the adults may overwinter under different climatic conditions, such as

obtain farther south. It is conceivable that even here they might survive under mild conditions.

If, as it appears, there is a southern area in which adults overwinter, and a northern area in which the winter is passed in the egg stage, it would be expected that along the border there would be a certain amount of fortuitous northward movement of the actively flying adults in the spring. If this has occurred, however, it has not been on a large enough scale to be reported in the literature.

The Egg, Oviposition, and Hatching

The egg of the rapid plant bug was described by Webster and Stoner (53). Having differed from their interpretation in certain minor respects, the writer therefore includes his own description, which is, however, more in the nature of a supplement to theirs than a correction.

The egg is elongate, slightly curved, and subcylindrical, being somewhat compressed in the region of the operculum, or cap. In length it varies from 1.15 to 1.3 mm, the maximum width being approximately 0.3 mm. The color of the fresh egg is milky white, with a greenish or a yellowish tinge, except for the cap, which is darker, often appearing somewhat reddish brown.

The outer face of the operculum is concave and, under

high magnification, appears to be sculptured. No definite pattern has been observed. There is some evidence of light sculpturing on the chorion just below the cap.

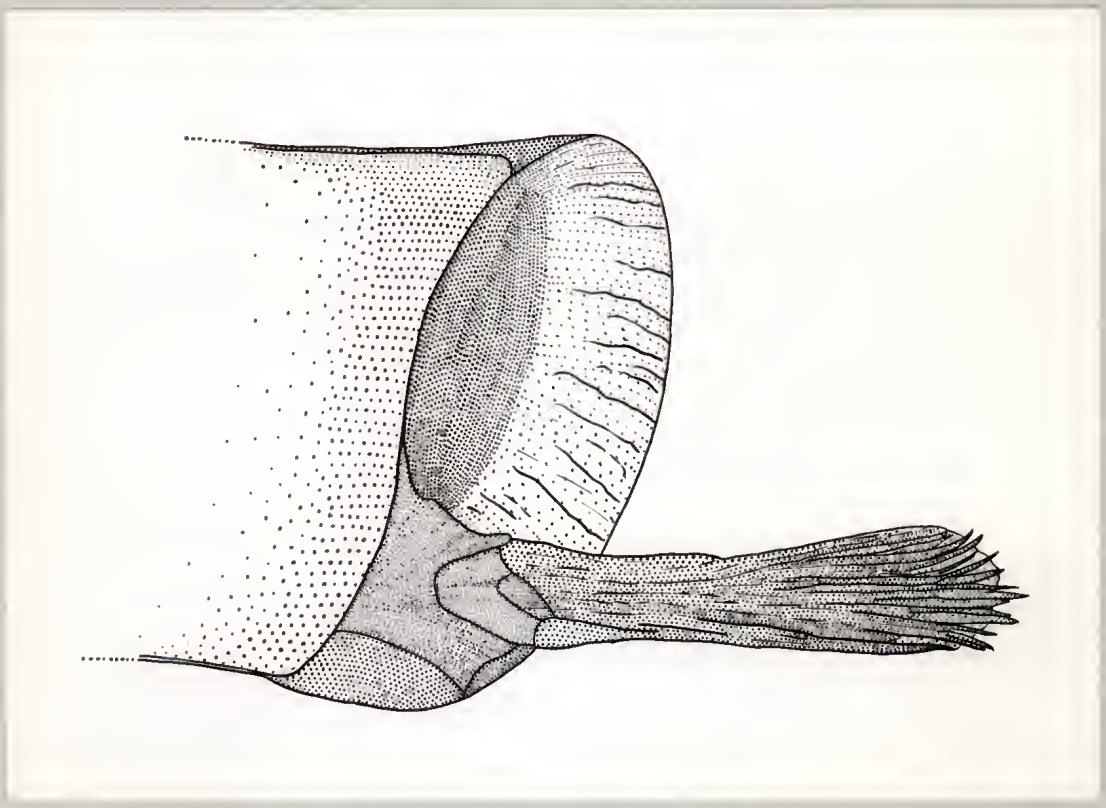

Fig. 1. End of rapid plant bug egg, showing operculum and fasciculoid process. (Greatly enlarged.)

At the edge of the operculum, and distal to the concave longitudinal curve of the egg, there is characteristically an elongate fasciculoid process which, to the naked eye, or under low magnification, appears spine-like (Plate II, Fig. 2). Under higher magnification it is seen to consist of many slender, sharp-tipped units, rather loosely united

and slightly spreading distally (Fig. 1). The function of the fasciculoid process, if it has any, is obscure. The process varies in length in different eggs, and not infrequently it is absent. It is sometimes straight, sometimes curved inward.

Webster and Stoner (53) reported that the eggs were easily obtained in the insectary, being deposited in potato stalks, most commonly where the smaller stems joined the main stalk, and in leaf axils, although considerable numbers were scattered along the main stalk. According to these authors the eggs were usually placed singly, but sometimes in close proximity, even adjacent. They described the position of the egg relative to the plant stalk as being usually at right angles to its long axis, although sometimes at an acute angle, or even parallel. Webster (53) wrote that the flat end of the imbedded egg was flush with the outer surface of the stalk.

The observations made in the present study, using alfalfa instead of potato, agree with the above findings, except that eggs in the alfalfa stems usually protrude a short distance above the surface of the stalk, instead of being flush. Very often the egg lies at an acute angle to the longitudinal axis of the stem (Fig. 2). Eggs have been seen inserted in a very narrow stem, with both ends protruding,

the length of the eggs exceeding the width of the stalk.

Fig. 2. Alfalfa stem split longitudinally to show rapid plant bug eggs.

It was uncommon to find a single egg in a stem. Often there were many, frequently arranged in one or more linear series. Two or more eggs placed very close together were not unusual, and as many as five have been seen clustered in a single cleft in the stem.

In the case of alfalfa, eggs are most commonly inserted within a few inches of the growing tip, where the tissues are relatively tender. The leaf axils are favored spots. Not infrequently an egg may be found loosely inserted in a flower or flower bud cluster.

The average number of eggs deposited by females has not been determined. It has been easy to obtain eggs from females taken in the field, and caged, but in no case have eggs been secured from a female reared through the immature stages in the insectary. Numbers of eggs obtained from females swept from the field constitute inadequate data, as such females may have deposited part of their eggs prior to being taken. The maximum number secured from such a female, however, was 51.

Records showing time elapsing between oviposition and hatching were kept for 99 eggs. The time varied from nine to 16 days, as shown in Table 1.

Table 1. Developmental period of the rapid plant bug egg.

Number of days from oviposition to hatching	Number of eggs represented
9	7
10	25
11	9
12	25
13	17
14	9
15	4
16	3
Total eggs represented	99

It will be seen by reference to Table 1 that the developmental period usually required 10-12 days. This approximates the findings of Webster (52), who reported that hatching occurred, in the cases observed by him, in 11 to 13 days.

On one occasion a nymph was discovered in the latter stage of emerging from the egg. The operculum had been pushed outward, and the nymph had extended two-thirds of its length from the egg when discovered. To facilitate the process, the nymph repeatedly bent backward, then straightened. This movement, together with the fact that the long beak and legs were lying back close against the body, imparted to the emerging nymph a somewhat worm-like appearance. After a few minutes it loosened its forelegs and brought them into play, after which it was soon free. The last parts to be removed from the egg shell were the dark ends of the long antennae. The entire body was considerably lighter than is true of nymphs even a few hours old.

Nymphal Stages

The nymphs of the rapid plant bug, at all stages, are very active, running about with great rapidity when disturbed. On various occasions they have been observed to

leap several times the length of the body.

First instars, if given an opportunity, will begin feeding almost as soon as they emerge from the egg. On one occasion, when several nymphs hatched in a test tube and were left for several hours without plant food, one individual was discovered with its beak inserted in the body of another, from which most of the fluid had been withdrawn.

Duration of stages. A careful determination of the duration of time of each of the five nymphal stages was attempted, but was only moderately successful, as a result of the difficulty of rearing nymphs under observation. Such data as were obtained are shown in Table 2.

Table 2 indicates that the duration of stages IV and V, especially, is quite variable, depending apparently on such factors as temperature and food.

Of four individuals reared directly through from egg to adult, one required 23 days, two required 24 days, and one 25 days. The time from oviposition to adult is therefore about 35 days. Variation which may occur, however, is indicated by the record of one nymph which hatched September 9 from an egg deposited August 28. Molting first occurred September 15, and again September 20, September 23, and October 1. The nymph became inactive about October 9,

Table 2. Duration of the nymphal stages of the rapid plant bug

	Number of individuals represented	Minimum number of days required for the stage	Maximum number of days required for the stage	Average number of days required for the stage
Stage I	5	5	6	5.17
Stage II	3	4	5	4.33
Stage III	8	3	4	3.88
Stage IV	12	3	8	4.58
Stage V	11	5	9	6.36

and died on the 11th, still a fifth instar. The total period from oviposition to death was 44 days.

Description of nymphal stages. Detailed descriptions of the five nymphal stages have been given by Webster and Stoner (53). These descriptions will not, therefore, be repeated in full. Instead, readily observed diagnostic characters which are of service in distinguishing instars in the field will be given.

In all nymphal stages the head and prothorax are reddish-brown in color; this provides an easy and conspicuous means of distinguishing nymphs of this species from those of the tarnished plant bug, which are entirely greenish.

Instars I and II (Plate II, Figs. 3 and 4). These two instars are the ones most difficult to distinguish. Webster and Stoner (53) described the abdomen of the first instar as being yellowish dorsally, without the red patch which covers most of the dorsal surface of the abdomen of the second instar. It has been observed, however, that in some cases, at least, the abdominal dorsum of the first instar is reddish.

In both first and second instars, the fourth antennal segment is the only one conspicuously darkened, being deep red except for a whitish tip and a short proximal area

which also is whitish. The first, second, and third antennal segments are usually light greenish-yellow, but in advanced second instars, the third antennal segment may be somewhat reddish distally.

Third instar (Plate II, Fig. 5). The distal one-third to one-half of the third antennal segment is deep red. The other antennal segments are approximately as in the preceding stage, except that occasionally the tip of the second may be tinged with red. This is most commonly seen within a day or two of molting to enter stage IV.

Nearly all nymphs of this stage show a conspicuous dorsal red spot on the abdomen, varying in extent from about one-half to two-thirds the total dorsal abdominal area. Only the caudal tip and a larger anterior portion are green. Usually this red spot is without very definite shape, but occasionally it may take on the appearance of a rough triangle, with the apex directed forward.

It is in this instar that wing pad development is first definitely evidenced, although even in this stage the pads are not conspicuous.

Fourth instar (Plate II, Fig. 6). The tip of the second antennal segment is characteristically a moderately deep red. The fourth antennal segment is essentially the same as in stage III; in the third, one third to one half

of the distal portion of the segment is dark. A reddish orange color, much lighter than the head capsule, characterizes the first segment.

The dorsal red coloration on the abdomen is often quite conspicuous, but not infrequently suffuse. In nearly all cases, it approximates the shape of a triangle, with apex forward. About half the dorsal surface of the abdomen is occupied by this spot, leaving a small green area at the tip, and a larger green area anteriorly.

The wing pads in the fourth instar are definite in appearance, and extend a short distance back over the abdomen. They are essentially greenish, though the tips may be yellowish, especially toward the end of the stage.

Fifth instar (Plate II, Fig. 7). The first antennal segment is reddish, sometimes as dark as the head capsule. The distal one-fourth to one-half of the second antennal segment is quite dark, with a short, conspicuously red band just proximal to the darker area, the relative length of which increases during the stage. Third and fourth antennal segments are essentially the same in appearance as in the preceding stage.

There is usually a rather well-defined reddish triangle situated dorsally on the abdomen, with the apex reaching to a point slightly to the rear of the wing pad tips in a

nymph with moderately distended abdomen. If the abdomen is shrunken, the apex of the triangle may lie between the tips of the wing pads. The reddish triangle occupies a smaller percentage of the dorsal area of the abdomen than in earlier stages. In some cases the reddish coloration is quite suffuse, and one nymph has been seen in which, a short time before the final molt, there was no visible red on the abdomen.

The wing pads are quite conspicuous in the fifth instar, extending far back over the abdomen. The tips are dark, often appearing black; the remainder of each pad is usually yellowish early in the stage. As the insect advances through this stage, there is a tendency for the duskiness of the tips to extend along the mesal margins of the wing pads, and for the rest of each pad to become olivaceous.

The Adult

A detailed description of the adult rapid plant bug was given by Blatchley (1). Parshley (25) wrote of the external anatomy of Adelphocoris rapidus and related forms.

The blackish coloration on the posterior portion of the pronotum is extremely variable in form. Commonly there are two more or less elliptical dark spots lying transverse to the longitudinal axis of the insect (Plate II, Fig. 8).

This pattern varies, however, from two relatively small, widely separated spots, to a condition in which there is a single, wide transverse band, usually with at least a slight concavity anteriorly. When the pronotal spots are divided, they may be approximately circular, rather than elliptical.

The adult rapid plant bug is quite active; it runs and flies with facility. It seems to be a less hardy insect than the tarnished plant bug, and dies more readily under experimental conditions. Observations have shown that in securing the bugs by means of sweepings, it is relatively easy to injure them fatally. It may well be that this lack of hardiness is at least in part responsible for their being normally less abundant than the tarnished plant bug.

Generations

The first reference to the number of annual generations of the rapid plant bug was that of Forbes (8), who stated that the broods were probably two in number, in Illinois. Two decades later he reiterated this opinion (10). Sanderson (30), working in Texas, reported several generations a year. In Iowa, Webster and Stoner (53) expressed belief in the probability of two generations at that latitude, the second appearing in late July and early August, and maturing in September. Their notes covered only the

seasonal period from mid-July on. Weigel and Sasscer (54) reported two overlapping generations a year, but did not cite any particular locality or latitude. Watson (50), writing of observations made in Ohio, stated that there were probably three broods over most of the state.

Efforts to determine accurately the number of generations at Manhattan, Kansas, have been greatly hampered by inability to obtain eggs from any female reared in the insectary. Several females so obtained were caged on alfalfa with males, but the majority died within a week or less, and none was kept alive for longer than 13 days. In no case were eggs found, although they were obtained without difficulty from most females swept from the field.

Such evidence as there is seems to indicate the normal occurrence of three full overlapping generations, and perhaps a partial fourth. Sweepings were taken at various intervals during the 1939 season. Until the latter part of June, neither nymphs nor adults were abundant in an alfalfa plot which was swept periodically, and the majority of nymphs taken were in advanced stages. On July 3, sweeping of the same plot revealed continued scarcity of adults, but nymphs were common, the greater part of them being early instars. It would appear that the hatching of the second brood occurred toward the end of June. These should have

reached the adults stage some 25 days later. Adults were first found in relative abundance about July 20.

Throughout August, nymphs were found in all stages, and were more abundant than adults, which were, however, common. Adults were relatively abundant through September. As late as September 28 all nymphal stages except the first were found in alfalfa on bottomland. Two fifth instars were taken October 15.

On the basis of the 1939 season, it appears that the first generation reached the adult stage toward the end of May, and began depositing eggs about the middle of June. The first and second generations were fairly distinct. The second generation appeared in nymphal form in late June and early July, and from then until the end of the season there was so much overlapping of broods that it was impossible to draw any accurate lines of distinction. In general, however, it seems that there were three full generations. The late nymphs mentioned above could have been either late members of the third generation, or representatives of a partial fourth.

Collection records and sweeping data show that August and September are the months during which rapid plant bug populations are normally highest.

INJURY TO ALFALFA

During the summer of 1939, experiments were carried on to determine the effect of rapid plant bug infestations on alfalfa.

Relation to Flower Drop

Dean and Smith (5) reported that Adelphocoris rapidus fed on alfalfa blossoms and caused them to drop. Similar injury had been attributed to a closely related species, Adelphocoris superbus (Uhl.), by Sorenson (36).

To test the effect of infestation on flowering alfalfa, there was set up a series of experiments in which adult rapid plant bugs were caged on alfalfa blossoms and buds. Whenever possible, the control in each case consisted of another flower cluster on the same plant, screened to exclude insects. Some of the plants used were growing naturally in the field; the majority were potted plants placed in a large screen cage out of doors.

From one to eight bugs were caged with each flower cluster infested, the clusters varying in number of flowers and buds from about six to some 25 or 30. In every case, within from two to five days after making the infestation, the flowers either wilted or fell (Fig. 3). Sometimes the

entire peduncle wilted a short distance below the cluster, causing the latter to droop.

Fig. 3. Effect of rapid plant bug infestation on alfalfa blossoms. Left, experimental stem. Right, control stem. Photographed after four days of infestation.

In some cases only female bugs were used, in other cases only males. It was hoped in this way to discover whether the entire injury resulted from feeding, or whether oviposition punctures might also be a contributing factor. As nearly as could be determined from the observations made, there was no difference. It is thought, therefore, that any

damage which may result from oviposition is of minor importance.

Similar flower and bud cluster infestations, in which nymphs were substituted for adults, were made. Five to ten nymphs of various stages were caged on each cluster, the number of flowers or buds per cluster varying as indicated above. The results obtained from these experiments differed in no essential respects from those involving adult bugs.

In no case did a flower belonging to an infested cluster develop to the point of forming a seed pod, regardless of whether one or several bugs were present, although normal seed pods were regularly obtained from the check plants.

Injury to Seed Pods

A series of experiments was begun August 23, 1939, to determine the result of infestation on young alfalfa seed pods. Ten clusters of apparently healthy young pods were selected in the field, and cages placed about them. In each of five of the cages, ten rapid plant bug nymphs of various stages were placed. The other five were used as controls. These experiments were kept under observation for a period of some five weeks in order to allow development of the pods, although the bugs in the infested cages died within a few days, in most cases. Then the plants were cut and the pods

examined. One infested plant was lost before examination could be made; the findings with regard to the others are shown in Table 3.

No pods were found on plant I, although a few very small pods had been present at the time of infestation. On plants II and IV the pods were shrivelled. Plant III had one pod, in fairly good condition.

On the control plants the pods appeared normal. Of the 37 seeds obtained from plant VIII, all but four were found to contain clover seed chalcids, but they were classed with the plump seeds because there was no evidence of the shrivelling typical of seeds in the Mirid infested cages.

Of the seeds obtained from the control plants, approximately 88% were plump, as compared with a corresponding percentage of some 17% in the case of the infested plants.

It will be noted that, as a result of rapid plant bug infestation on young alfalfa seed pods, there is a reduction in total number of seeds produced, as well as a marked reduction in the percentage of good seeds among those which are formed.

Table 3. Rapid plant bug injury to young alfalfa seed pods.

	Plant Number	Plump seeds	Slightly shrunken seeds	Badly shrivelled seeds	Total seeds obtained
Infested plants	I	0	0	0	0
	II	0	5	0	5
	III	4	0	1	5
	IV	0	0	13	13
Totals for infested plants		4	5	14	23
Control plants	V	12	3	1	16
	VI	7	1	1	9
	VII	3	0	0	3
	VIII	35	2	0	37
	IX	5	0	0	5
Totals for control plants		62	6	2	70

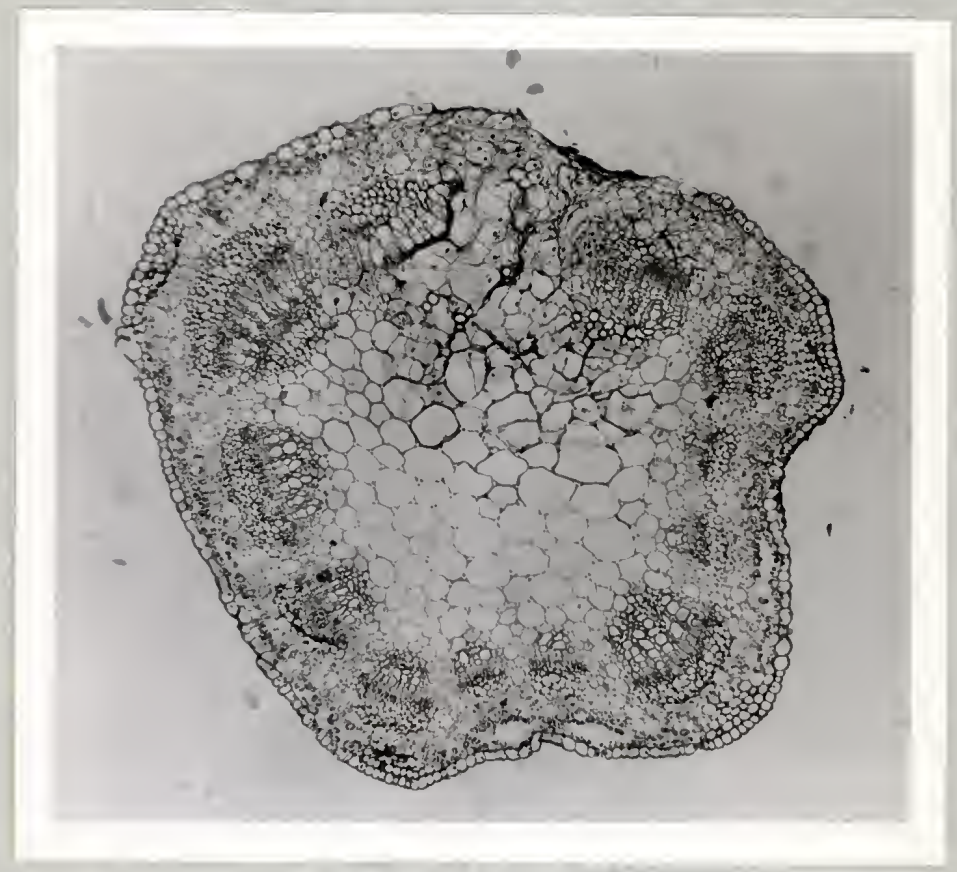

Fig. 4. Cross-section of alfalfa stem showing (top center) feeding puncture of rapid plant bug. (Fixed in formal-acetic-alcohol; stained with alum-haematoxylin and triosin).

Effect of Feeding Puncture on Plant Tissue

In order to observe the histological effect of feeding punctures on alfalfa stems, cross-sections have been secured and mounted for study (Fig. 4). The evidence at hand indicates that the rapid plant bug does not feed exclusively on one type of plant tissue, but that the relatively large

stylets enter the stem more or less at random, so far as vascular bundles are concerned. The most apparent result is a general collapse of cells of all types in the vicinity of the puncture. Whether or not a toxic substance is secreted has not been established. Detailed study of the anatomical and physiological effect on the plant is needed.

CONTROL

No practical method of control of the rapid plant bug is known, but various chemical and cultural methods of some merit have been suggested.

Apparently the first suggestion for chemical control came from Sanderson (31), who thought that a kerosene emulsion or similar contact insecticide should prove effective against the nymphs. A study of the effect of dusting cotton with sulphur, for the control of various cotton insects, including A. rapidus, was made by Hamner (17), who found that by using 27 pounds of 300 mesh sulphur to the acre, an average increase of 275 pounds of seed cotton per acre was obtained. The rapid plant bug was, of course, but one of several injurious species affected.

In recent years, extensive studies have been made in the alfalfa growing districts of Utah, Arizona, Idaho and California on control of Lygus bugs and Adelphocoris

superbus in alfalfa. In view of the many points of similarity of these bugs to A. rapidus, findings concerning the control of one are of interest in regard to the others. Sorenson (37) reported that black colloidal sulphur gave evidence of some repelling action. Westover (55) stated that fair control was obtained through frequent dusting with 15 parts pyrethrum concentrate and 85 parts commercial dusting sulphur.

In the present study, a dust composed of 10 parts Pyrocide to 90 parts Georgia talc has been used on the rapid plant bug in cage experiments. Almost immediate distress was evident, and under relatively heavy dosage there was a definite insecticidal effect. Moderately heavy dusting, however, was not found to give complete control, even in a cage, where the bugs could not escape. It was observed that small droplets of fluid quickly appeared on the beaks of rapid plant bugs subjected to the dust.

The most common suggestion for cultural control of the rapid plant bug has been destruction of wild host plants. Pettit (27) advised elimination of lambs'-quarter and ragweed. Destruction of composites, which might serve as hibernating quarters, had already been urged by Weigel and Sasscer (54).

Sorenson (37) stated that early cutting seemed the best

of the cultural methods for control of tarnished and superb plant bugs. Stitt (39), in reporting on his work with Lygus bugs as alfalfa pests, observed that migration seemed to be caused by reduction of the food supply through cutting of hay, or the maturing of the seed crop. He suggested, therefore, that unity of "cropping" offered a possible control method, by prevention of huge concentrations of bugs in fields where optimum conditions prevailed.

It appears that the chief value which might be derived from using chemicals against the rapid plant bug would be realized in the case of seriously infested seed crops. Repeated dustings from the time of bud formation to maturation would often be necessary, as the bugs migrated in from adjacent areas. The variable relationship of cost of dusting to the value of seed saved remains a problem.

Insofar as alfalfa hay crops are concerned, early cutting is undoubtedly advantageous when a severe infestation of plant bugs exists, as it removes not only food but also much-needed protection, which is important to the nymphs, especially.

Resistance and tolerance of alfalfa to plant bugs have come to be recognized as worthy of investigation, but remain yet to receive adequate study.

Apparently the only record of destruction of rapid

plant bugs by natural enemies is that of Isely (20), who reported that the big-eyed bug, Geocoris punctipes (Say), as well as spiders, red mites, lady beetles, and lacewing larvae, fed on nymphs and adults.

Lacewing larvae have been observed feeding on nymphs in the field. Nabids are probably enemies. Nymphs left overnight in a cage with an adult of the genus Nabis were found dead next day. The bodies of the nymphs had the appearance of having been sucked dry. Nabids are often among the most common insects in alfalfa at Manhattan, Kansas, and it seems probable that they play a significant part in reducing nymphal populations of the rapid plant bug, and other soft-bodied insects. The rapidity with which A. rapidus nymphs move is undoubtedly of great value to them in escaping such enemies.

SUMMARY

1. In the vicinity of Manhattan, Kansas, the rapid plant bug Adelphocoris rapidus (Say), appears normally to overwinter in the egg stage, in the stems of herbaceous plants.

2. The time elapsing between oviposition and hatching varies at least from nine to 16 days, with the majority of cases falling within a 10-13 daysrange. Duration of nymphal

stages varies according to environmental factors, especially in stages IV and V. The total period from hatching to the adults stage appears usually to approximate 24 days.

3. Diagnostic characters for distinguishing nymphal instars in the field have been recorded.

4. There appear to be three full generations, and perhaps a partial fourth, at Manhattan, Kansas.

5. Both adults and nymphs are capable of bringing about marked reduction of alfalfa seed, through causing buds to become blasted, flowers to drop, or the seeds in young pods to become shrivelled.

6. Damage to tissue in the alfalfa stem, as a result of feeding punctures, seems to consist primarily of a general collapsing of cells in the vicinity of the puncture.

7. No adequate control has been devised. Early cutting seems advisable for heavily infested alfalfa hay crops, as it not only saves that crop from further injury, but also lays a stress on the rapid plant bug population by removing food and shelter.

Certain predaceous insects apparently aid in reducing the nymphal population.

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EXPLANATION OF PLATE I

Fig. 1. Distribution of the rapid plant bug in the United States. States from which specimens have been reported, or seen by the writer, are shaded.

PLATE I

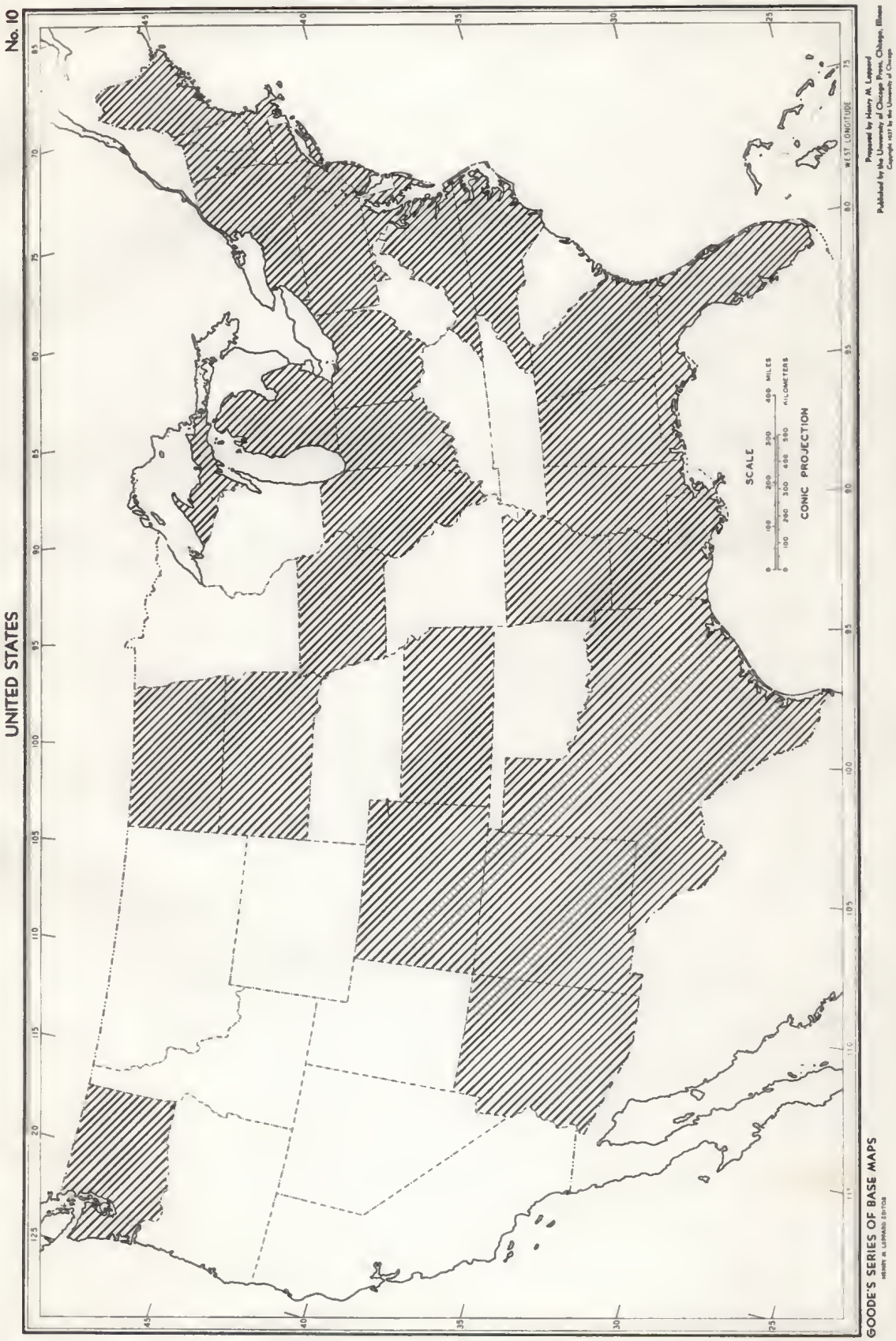
No. 10
UNITED STATES
SCALE
CONIC PROJECTION
WEST LONGITUDE
GOODE'S SERIES OF BASE MAPS

Fig. 1

EXPLANATION OF PLATE II

Fig. 2. The egg.

Fig. 3. First instar.

Fig. 4. Second instar.

Fig. 5. Third instar.

Fig. 6. Fourth instar.

Fig. 7. Fifth instar.

Fig. 8. The adult.

PLATE II